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The Measurement of Hospital Case Mix

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Improved Cost Allocation in Case-Mix Accounting

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Traditionally, many hospital costs have been allocated to patients using indirect measures that do not always reflect the value of the resources used to provide care. When, for example, costs are allocated by multiplying the patient's charges by the hospital's ratio of costs to charges, the allocated cost does not reflect actual cost because the hospital does not uniformly charge for services in proportion to their cost. The choice of method for cost allocation will be as important for the newly developed case-mix cost-accounting systems as it has been for traditional cost-accounting systems. To illustrate how the use of an indirect cost-allocation method might affect the output of a case-mix cost-accounting system, operating room, radiology and clinical laboratory costs were assigned to 106 hospitalized inguinal hernia patients in two diagnosis-related groups (DRGs) using both the hospital's existing cost-allocation method and a method that measures costs directly. Total costs and the costs in each department were significantly lower in each DRG using the direct method. It was concluded that patients in these two DRGs were being assigned more than the actual cost of their care with the existing cost-allocation method and, therefore, that the existing method prevented the case-mix accounting system from providing accurate management information.

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RECENT INTEREST in the control of hospital costs has led to increased concern about how the costs of medical services are determined. In the past, attempts to associate costs with the hospital's products have not been convincing because hospital products are difficult to define. Simple measures of productivity, such as the number of patients admitted or the number of patient days, remain unsatisfactory because of the wide variation in inputs and costs from patient to patient.[1–4] To address the problem of defining hospital products, a patient classification system that separates the patients into 383 diagnosis-related groups (DRGs) has been proposed.[5–10] Each DRG is composed of a group of patients with similar diagnoses and lengths of stay. The hospital's products are defined as the bundle of services that the hospital provides to each of the 383 groups, and specific costs are assigned to each bundle.

The DRG system is only one of several case-mix measures that have been pro-

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posed, but it is the most developed and most widely used.[11] Significant problems are being identified with the DRG system as more experience is gained using it,[11–14] especially as a method for reimbursing hospitals prospectively for patient care.[10,15–17] Nevertheless, case-mix measures such as the DRG system probably represent a significant step forward for hospital management because they permit the hospital administrator to control operations, to plan and to budget more effectively, and they may facilitate the planning of regional services.[9,10,18] However, the new method's potential cannot be realized if costs are not accurately assigned to each DRG.

At present, hospitals generally assign most patient-care costs to functional cost centers, such as the departments of radiology, nursing and maintenance. Costs are then assigned to patients based on their use of each department's services or on a per diem basis. Assigning costs on a per diem basis means that all patients are assigned an average cost regardless of the cost of the services actually used. Moreover, even when patients are assigned costs based on their use of services, the cost-allocation method often does not recognize the real differences in cost among different services, but substitutes costs that have been measured indirectly and thus may be inaccurate. Both of these approaches obscure the relationship between a group of patients and the resources they consume. Unfortunately, these same cost-allocation methods have been used to assign costs to the products defined by the DRG system.[8,10,16]

Allocation of operating room costs illustrates the problem. Consider how surgery charges are usually determined. All operating room costs are accumulated, and the total is divided by the total minutes of operating time. The charge is then calculated, based on a cost per minute of time in the operating room. Operating time, however, is an inadequate measure for resource consumption. Some short procedures require more expensive equipment, more supplies and more total personnel time than do longer procedures. This problem might be avoided if more direct measures were used to assign operating room costs.

To illustrate how this might change the allocation of costs, we report here a pilot project using a cost-allocation method that assigns many departmental costs directly to patients based on cause and effect. The new system is compared with a traditional allocation system that differs from the new system in that the traditional system assigns departmental costs to patients indirectly, based on the departmental cost-to-charge ratio multiplied by the patients' departmental charges.[19]

Methods

The project was conducted at the Hospital of the University of Pennsylvania, a 694-bed university teaching hospital. Patients in two diagnostic-related groups were included, DRG 198 and DRG 199. Patients in both groups had a primary discharge diagnosis of inguinal hernia, without obstruction, and were between the ages of 14 and 65 years. Patients in DRG 198 did not and patients in DRG 199 did have a major secondary diagnosis.

The medical records of all patients discharged in 1978 with a primary diagnosis of inguinal hernia were reviewed. Of the 192 patients whose discharge abstracts were coded for inguinal hernia, 60 were over the age of 65 and thus were not included in the two DRGs by definition, 15 actually had a diagnosis other than inguinal hernia, and for 11 it was not possible to match the record with the patient's bill. Of the remaining 106 patients included in the study, 69 were in DRG 198 and 37 were in DRG 199. All 106 patients underwent operations to repair their inguinal hernias.

Two methods were used to allocate costs to the 106 patients. Both cost-allocation

methods were restricted to three cost centers—the operating room, radiology and the clinical laboratories. Other cost centers were not examined, and hospital overhead costs, such as hospital administration and building depreciation, were excluded from the calculations.

The Direct Method

The direct cost-finding method is a variation of the component-enumeration method,[4] which was adapted to this project.

With the direct method to allocate costs to each patient, the first step was to divide the costs from each functional cost center into 1) departmental overhead, such as office supplies, equipment depreciation, and salaries for departmental administrators and supervisors; and 2) direct costs, such as supplies and salaries, that were committed to direct patient care (Fig. 1).

The second step was to choose a way of allocating the departmental overhead to individual patients. For the operating room, the departmental overhead was divided by the total number of operations to yield an overhead cost per operation, which was assigned to each patient. For the radiology department and the clinical laboratories, departmental overhead was divided by the number of procedures, and each patient was assigned a departmental overhead cost that was proportionate to the number of procedures performed in the inguinal hernia patients.

The third step was to assign direct departmental supplies and salaries to inguinal hernia patients. For the operating room, a list of supplies consumed during a typical inguinal hernia operation was prepared and verified by interviewing operating room nurses, supply clerks and surgeons who performed inguinal hernia operations. These supplies were designated as either variable or fixed supplies. The variable supplies consisted of disposable items, such as medical–surgical supplies and paper sheets and gowns that were used only once. They were counted, and their costs were determined for assignment to each patient.

It was more difficult to assign the cost of fixed supplies to each patient. The fixed

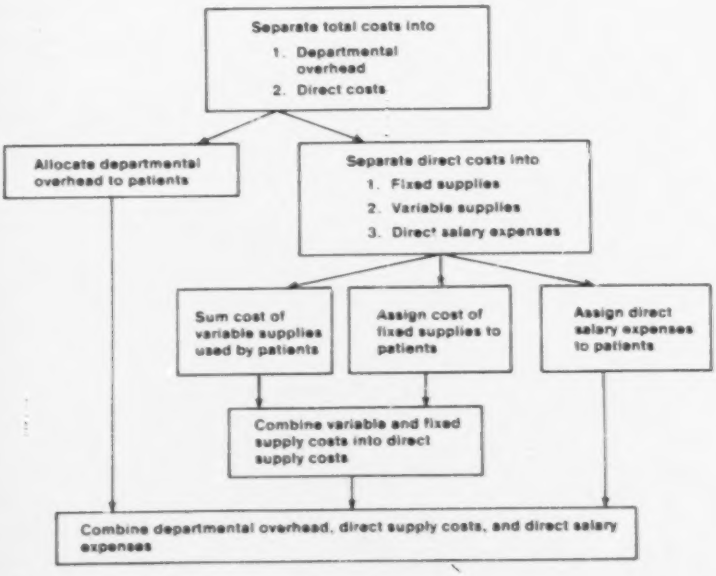
Separate total costs into
1. Departmental overhead
2. Direct costs
Allocate departmental overhead to patients
Separate direct costs into
1. Fixed supplies
2. Variable supplies
3. Direct salary expenses
Sum cost of variable supplies used by patients
Assign cost of fixed supplies to patients
Assign direct salary expenses to patients
Combine variable and fixed supply costs into direct supply costs
Combine departmental overhead, direct supply costs, and direct salary expenses

FIG. 1. The direct method for cost allocation.

supplies consisted of laparotomy instrument sets, major large basin sets and other reusable supplies. The cost per operation of fixed supplies, such as instrument sets, was determined by multiplying the cost of each instrument set by the number of sets to get a total cost, and then dividing by the number of operations in which those supplies were used and correcting for the expected useful life of the set in years. Variable and fixed supply costs were added together to yield the total direct supply cost, which was then assigned to each patient.

To assign direct salary expenses in the operating room, interviews and observation were used to determine how many hospital employees worked with a typical inguinal hernia patient. An average of one circulating and one scrub nurse worked with each patient throughout the operation. Anesthesia time was obtained from the anesthesia records in each medical record. The average operating room nurse salary for 1978 was inflated by 30 per cent to account for fringe benefits. The hourly salary for two operating room nurses was multiplied by total anesthesia time, resulting in total departmental salary expense per operation.

The costs of direct departmental supplies and salaries in radiology and the clinical laboratories were assigned to inguinal hernia patients using existing measures. The radiology department has determined the direct costs for x-ray procedures based on measures of personnel time and the consumption of supplies similar to those used for the operating room. In the clinical laboratories, measures of direct costs that were based on the amount of personnel time required to complete each test as published by the College of American Pathologists were used.[20] In both departments, the direct cost of each procedure was multiplied by the recorded number of procedures used by inguinal hernia patients to arrive at the total costs of direct departmental supplies and salaries.

To summarize the direct method, the total cost allocated to inguinal hernia patients included the costs of 1) departmental overhead; 2) direct departmental salaries; and 3) direct departmental supplies, which included the costs of both variable and fixed supplies. Using the direct method, departmental overhead is allocated indirectly, but most departmental salaries and supplies are assigned directly to patients.

The Traditional Method

The traditional method uses the ratio of departmental cost to charges multiplied by the patient's recorded charges. The 1978 total departmental expense for each cost center, before allocation of hospital overhead, was obtained from the 1978 Medicare Cost Report. This amount was verified against fiscal year-end operating room departmental expense statements and was adjusted if necessary. Total charges for that cost center were also obtained. These amounts were used to calculate the cost-to-charges ratio for each cost center. These ratios were multiplied by the charges recorded on each patient's bill to determine an adjusted cost estimate (Fig. 2). Cost estimates from each department were added to produce each patient's total costs. With the traditional method, all departmental costs are allocated indirectly, using measures such as operating room time or the average cost of diagnostic procedures.

Statistical Analysis

The two-tailed Student's t-test for paired samples was used to test for significant differences between the costs determined by the two methods when applied to the same patients. Significance was accepted if p was less than or equal to 0.05.

Results

Within each DRG, the total cost and the costs for each cost center determined by the direct method were significantly lower

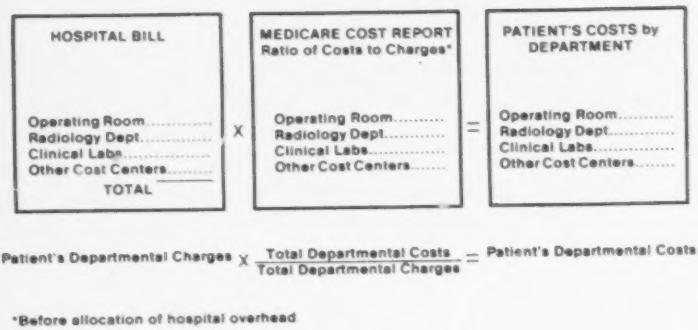

FIG. 2. The traditional method for cost allocation.

than the costs determined by the traditional method (Tables 1 and 2). The costs for patients in DRG 198, who did not have major secondary diagnoses (Table 1), are seen to be lower in all three departments than those for patients in DRG 199, who did have major secondary diagnoses (Table 2) when the costs in one table are compared with the costs in the other table determined by the same method. The major determinant of differences in operating room cost, which contributed an important part of the differences in total costs between the two DRGs, was the duration of anesthesia time, which varied from 30 to 210 minutes.

Discussion

Two different cost-allocation methods were used to assign the costs from three departmental cost centers to patients who underwent inguinal hernia operations. The traditional method is the method that is used almost universally, with modifications, for allocating costs under traditional accounting systems and under the newer case-mix accounting systems. The direct method differs from the traditional method because it uses more direct measures to allocate the costs of services to patients who used those services.

The direct method that was used to assign operating room costs differed substantially from the traditional method. Using the direct method, many operating room services were associated directly with inguinal hernia patients, and the number and the costs of these services were determined separately from the number and the costs of services provided to all other patients. Using the traditional method, the costs of the services provided to inguinal hernia patients were first averaged with the costs of the services provided to all other patients and then allocated using a measure (operating room time) that only indirectly considered the number of services provided to inguinal hernia patients.

TABLE 1. Comparison of Mean Costs Determined by Two Methods of Assigning Costs to Patients in DRG 198 (Inguinal Hernia, Without Major Secondary Diagnosis)

Method	Total Cost	Operating Room Cost	Radiology Cost	Clinical Laboratory Cost
Direct	$123.51 (36.88)*	$ 89.76 (12.94)	$7.43 (3.12)	$26.32 (10.40)
Traditional	$184.97 (17.49)	$143.57 (32.58)	$9.40 (7.04)	$32.00 (13.37)

* Standard error in parentheses.

The direct method that was used to assign the costs of services from the clinical laboratories and the radiology department differed from the traditional method only in the way the cost of each service was determined, not in the way the number of services was counted. In both methods, simple examination of existing records was used to determine exactly which and how many diagnostic procedures were performed for each patient. By the direct method, the cost of each procedure was determined from existing measures of the amounts of time and supplies that were used to conduct the procedure. By the traditional method, the cost of each procedure was determined by less exact measures that were developed to insure accurate recovery of overall departmental costs and thus relied more on average costs for categories of procedures.

To determine the costs for each DRG, some costs are variable and direct, and the number used for each DRG can be counted easily from existing records, as was done here for diagnostic procedures. All that needs to be done to assign accurate costs for these services to each DRG is to measure each separate cost accurately. The traditional accounting method treats some costs that are variable and direct as if they were shared costs. To assign accurate costs for these services to each DRG requires first that the services be separated and accurately counted, and then that their separate costs be accurately measured, as was done here for many operating room services. However, some costs are truly fixed, indirect and shared, such as operating room overhead, and their allocation requires special methods that are described below.

This pilot study looked at only part of the costs for a limited number of patients in one hospital. The results should not be broadly generalized. Nevertheless, they illustrate that, at least in some situations, there are important differences in cost when the two different methods are used. In this pilot project, the direct method identified costs that were uniformly lower than the costs identified using the traditional method.

These results strongly suggest that some cross-subsidization was occurring with the traditional method. It is hypothesized that inguinal hernia patients, who receive relatively standard care, are charged more than their care costs to subsidize other patients who receive complicated care and are charged less than their care costs. The hospital might set charges to encourage cross-subsidization for a variety of reasons. The hospital might, for example, determine that some uncommon, complex procedures are so expensive that they could not be paid for by the patients who need them unless they were supported by relatively small subsidies drawn from the many patients who required less complex and expensive procedures. Alternatively, the hospital might set charges for emergency room services below cost, thus encouraging use of the emergency room earlier in the patient's ill-

TABLE 2. Comparison of Mean Costs Determined by Two Methods of Assigning Costs to Patients in DRG 199 (Inguinal Hernia, With Major Secondary Diagnosis)

Method	Total Cost	Operating Room Cost	Radiology Cost	Clinical Laboratory Cost
Direct	$201.74 (112.52)*	$118.06 (42.32)	$20.97 (26.68)	$62.71 (85.21)
Traditional	$310.43 (482.49)	$204.01 (98.27)	$30.94 (43.72)	$75.48 (102.77)

* Standard error in parentheses.

ness. The hospital would recover the difference from inflated charges to hospitalized patients, many of whom would have been admitted through the emergency room. In both cases, cross-subsidization may be in the public's interest and, therefore, be tolerated or even encouraged by third-party payors. Nevertheless, the information provided by the existing cost-allocation method is misleading.

It is possible, but less likely, that the total of all charges to inguinal hernia patients accurately reflects their total costs because the overcharges observed during this study are balanced by undercharges for services not examined. In this case, the information provided by the existing cost-allocation method is also misleading.

The evidence for cross-subsidization might have been stronger if the same methods had been used to measure costs for patients in a high-cost DRG that involved complex procedures or in some other DRG in which inflated charges might be expected. This was not done, however, because of limited time and resources.

These results also illustrate how the choice of a cost-allocation method could affect the operation of case-mix hospital accounting systems. Some cost-allocation methods obscure the relationship between patients and the resources they consume, and other methods describe the relationship more clearly. While case-mix accounting systems provide improved definition of hospital products in any case, it is only when the cost-allocation method accurately links resource consumption with those products that the full benefit of the system can be realized.

Even with the direct method, some costs, such as operating room overhead, are fixed, indirect and shared costs that cannot be allocated easily. Operating room overhead is a fixed cost; that is, a cost per patient cannot be computed without considering patient volume. It is also a shared cost that cannot be easily separated and assigned to the activities that cause it to arise. Since the cost is indirect, there is also the problem of associating the cost with particular patients in DRGs. If eight DRGs all make use of the operating room, it is difficult to decide how to allocate costs among the eight. A proponent for each DRG in turn could point to the other seven DRGs and note that the operating room would be needed for those seven, even if the eighth did not require it. Therefore, its use by the eighth DRG imposes no additional cost, and so no cost should be assigned to the eighth DRG for use of the operating room.

For decision-making purposes, the correct theoretical treatment of shared costs, such as those for the operating room, is to ignore them, since accounting theory calls for marginal cost pricing for optimal resource allocation. Thus, theoretically one should not be concerned with assigning shared costs to any particular DRG. The cost would be incurred even if the DRG were not offered. Obviously, however, this does not help the hospital administrator determine costs for pricing and reimbursement. All costs must be assigned to DRGs, or the hospital will not be able to recover all of its costs.

There are seven solutions to this allocation problem: 1) cause and effect; 2) ability to bear; 3) relative prices; 4) fairness for pricing; 5) equity; 6) physical units; and 7) benefits available.

With *cause and effect*, one assigns to a DRG the costs that it causes to be incurred. This method is preferred if a cause-and-effect relationship can be found, but, unfortunately, this is often not the case. When cause and effect cannot be determined, more arbitrary allocation bases are required.

Ability to bear is a frequently used basis for cost allocation in profit-oriented businesses. It assumes that some products can better bear the cost of large allocations. It allocates a large share of cost (e.g., the cost of the corporate president's salary) to the most profitable products or to those

with the largest sales. The extra cost is a smaller proportionate burden for these products; the idea is similar in philosophy to that of a progressive income tax. Allocating costs to DRGs according to their ability to bear would continue the cross-subsidization that is a disagreeable feature of the current cost-allocation systems.

When prices are known, costs are often allocated based on the *relative prices* for each product. Thus, if the outside marketplace has decided that one DRG is worth twice as much as another, then one assigns two shares of joint cost to the first and one share to the second. Since hospital prices are not based on the consumer's utility but are based on costs measured in one way or another, assigning hospital costs based on relative prices is circular reasoning.

When outside market prices are not known, cost allocation is sometimes based on *fairness for pricing*. The goal of this method is to allocate costs in a way that ultimately achieves a fair set of prices. This method is commonly used for defense contracting, where the issue is to determine which costs will be borne by products sold to the government under a cost-plus contract and which by products sold to other buyers. It is, however, extremely difficult to determine what constitutes a fair set of relative hospital prices. In the absence of a generally acceptable standard of fairness, this method should not be used for hospital cost allocation.

The same problem exists when relying on the general concept of *equity*. Unfortunately, different people will have different concepts of what allocations are equitable. For example, if certain DRGs are related to patients' ages, one might expect Blue Cross and Medicare to differ in their opinion about an equitable allocation of costs to those DRGs because their clients have different characteristics, especially with respect to age.

Costs could be assigned on the basis of *physical units*, for example, the number of admissions for each DRG or the number of patient days. While the physical unit selected would clearly be arbitrary, at least it could be measured. This method may be useful as a last resort when other alternatives fail.

Benefits available is the final measure. For example, a stand-by defibrillator's cost could be assigned to patients who actually make use of the defibrillator in proportion to their use, as is done under cause and effect. Alternatively, one could argue that it was available for the use of patients in all DRGs or in some group of DRGs. An argument could be made for sharing costs among all patients who had the equipment available for their use. The authors propose that when direct cause-and-effect relationship does not exist, the preferred method for cost allocation is benefits available, although they did not use this method to allocate the shared cost of operating room overhead.

Since the direct cost-allocation method was not used in this study to measure all the costs of all the patients in each department, it was not possible to check for overlooked costs by comparing the sum of all patients' departmental costs with the department's overall costs. Therefore, the possibility exists that some costs were inadvertently excluded with the direct method, which would have lowered the costs measured with the direct method and could have explained the differences observed between the two methods. The authors consider this an unlikely explanation because differences between costs using the two methods were relatively uniform in all three departments and because of the care that was taken to avoid this problem when collecting information, especially in the operating room.

This pilot project did not provide information about the cost of collecting the additional information needed to allocate costs directly to patients under the new direct cost-allocation method. Whether the collection of additional information will

substantially increase cost, and whether the increased cost will be offset by the benefits of a more accurate cost-accounting system, are questions that should be answered by larger and more comprehensive research projects. Ernst and Whinney, a major accounting firm, has developed a cost-allocation system under the sponsorship of the Illinois Hospital Association, similar to the one the authors propose,[22] and is presumably testing it for cost-effectiveness. Fetter has used a direct method to allocate costs under a case-mix cost-accounting system in the Department of Radiology at the Yale-New Haven Hospital.[18] She was able to determine which year-to-year variances in cost were the result of changes in the department's operating efficiency, which the result of changes in patient mix, and which the result of changes in the clinical practices of the medical staff. She concludes that such a powerful accounting system ought to be worth its cost but does not provide information about the actual cost of the system.

Finally, improved cost allocation could lead to improvement in the case-mix measures themselves. Diagnosis-related groups, for example, are formed by identifying patients with similar diagnoses and lengths of hospital stay, using length of stay as an easily determined but indirect measure of the bundle of services used by patients in the DRG. Several investigators are attempting to develop improved classification systems in which patients with similar diagnoses have similar costs instead of similar lengths of stay, because cost should be a more accurate measure of resource consumption.[23] These efforts, however, depend on existing cost-allocation methods, with their problems of inaccurate information and cross-subsidization. Further improvement would be expected if case-mix measures could be developed using data from a more accurate cost-accounting system with an improved cost-allocation method such as the one proposed in this article.

Conclusions

The current DRG cost-accounting system should be refined to provide a clearer assessment of 1) which costs should be assigned directly to patients in specific DRGs; 2) which costs are fixed, indirect and shared costs that require allocation; and 3) which allocation method and bases should be used.

Clearly, there is no one method for allocating costs to DRGs. Costs that are variable, direct and separable should be assigned to specific DRGs using simple measures of the number of services already available in the medical record and more accurate measures of the cost of each service.

At present, there are alternative ways of assigning other costs. Accuracy will be improved if more costs that are treated as fixed and indirect costs in traditional accounting systems are assigned instead to specific DRGs using methods based on cause and effect.

We propose allocating truly joint costs using the method of benefits available. Alternatively, it may be possible to choose one of the other methods we describe, at least in special situations, if there is a defensible rationale for choosing that method over the others.

The use of more accurate methods of cost allocation will serve several purposes. It will assist hospital administrators in determining whether charges accurately reflect the cost of the resources used to care for individual patients. It may be used by third-party payors to establish equitable reimbursement schemes that do not penalize hospitals that care for more complex patients who require more costly services. It may provide better information for regional planning. It should provide hospital managers with one of the instruments they need to improve planning, budgeting and control of hospital operations. It may lead to improvement in the case-mix measures themselves.

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Three Case-Type Classifications: Suitability for Use in Reimbursing Hospitals

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This study compared three case-type classifications—the cross-classification of the Commission on Professional and Hospital Activities, Diagnosis-Related Groups (DRGs) and Staging—with respect to per cent of variance in total patient charges accounted for. The purpose was to assess the relative usefulness of the classifications for application in hospital reimbursement schemes. The sample consisted of 50 hospitals. A nested analysis of variance was performed with case type nested within hospital. Per cent of variance accounted for was calculated for each of three data sets: the full data set, a truncated version of that set and a logarithmically transformed version. Results support the contention that none of the currently available classifications accounts for enough variance to permit straightforward use of case-type standard costs in a reimbursement mechanism. New developments in case-type classification may result in a classification that is more suitable for this use.

INFLATION-ADJUSTED EXPENDITURES for hospital goods and services have risen at an average annual rate of 8 per cent since 1960.[1] During that same period, proportionately more health care has been paid for by third-party payors, including federal and state governments through Medicare and Medicaid programs. Concerned third-party payors have begun to experiment with alternative reimbursement schemes in attempts to slow the steady increase in expenditures for hospital goods and services.

With the hope of eliminating inflationary incentives in retrospective reimbursement methods, experiments with prospective reimbursement schemes are being conducted in which the reimbursement rates for hospital goods and services delivered to patients are set prior to the period in which costs are incurred. Research results indicate that selected prospective schemes are experiencing some success in containing health care expenditures.[2] The National Hospital Rate Setting Study, now in progress, will attempt to identify characteristics of effective prospective reimbursement mechanisms.

Any reimbursement scheme should set standards for the allowable cost of goods and services, preferably taking case mix into account. Case mix is defined as the proportion of patients falling into mutually exclusive case types. The per-case system of taking case mix into account is to set a separate standard for each case type in some classification of patients and to reimburse accordingly. The equity of this

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method depends in part on the characteristics of the case-type classification used.

We have argued elsewhere that a case-type classification for use in hospital reimbursement should have a number of specific qualities.[3] The quality of major importance in this discussion is economic meaningfulness. By this is meant homogeneity of patients' resource needs within a case type.

Using the charges for resources delivered to a patient as a proxy for the patient's resource needs, this study empirically evaluates the economic meaningfulness of three available case-type classifications: the cross-classification of the Commission on Professional and Hospital Activities, Diagnosis-Related Groups (DRGs) and Staging. More equitable reimbursement patterns will result when a case-type classification that exhibits a relatively high degree of economic meaningfulness is employed. None of the studied case-type classifications was developed with economic meaningfulness as the sole characteristic of importance, and all of them aggregate patients into broad diagnosis groups that are subsequently stratified.

The cross-classification of the Commission on Professional and Hospital Activities, in its original version, aggregates *H-ICDA-2* principal diagnosis codes into the 349 categories of CPHA List A: Hospital Diagnosis Groups, each of which is further categorized to define case types. Stratification into case types is symmetric across diagnosis groups. In this study, each diagnosis group is divided into ten categories based on presence or absence of operations, and five broad age groups. Stratifiers were selected because of their relationship with length of stay and severity of illness. List A was developed for use in the review and evaluation of care of hospitalized patients; the further stratification, supplemented by a split on presence or absence of secondary diagnoses, has been used for presentation and analysis of length-of-stay statistics.[4]

Diagnosis-Related Groups aggregate patients in such a way that any case type is reasonably homogeneous with respect to length of stay. An interactive statistical analysis system, AUTOGRP, was used to partition patient data, using length of hospital stay as the dependent variable and a collection of independent variables similar to those of the Uniform Hospital Discharge Data Set. Variables selected to stratify Diagnosis-Related Groups are as follows: primary diagnosis, secondary diagnoses, primary surgical procedure, secondary surgical procedures, age, and the presence or absence of a psychiatric service. All diagnosis groups were initially aggregated by clinicians into 83 broad, mutually exclusive, major diagnostic categories. Further division of each major diagnostic category into specific case types was an iterative process, and decisions were based on a number of factors, including the reduction in the within-group sum of squares attained by the grouping, the number of groups and clinical decisions. Diagnosis-Related Groups were developed as an aid in utilization review.[5]

Staging formed original diagnosis groups, called disease conditions, by identifying the organ system affected by the disease and the cause of the disease. A panel of physicians defined the disease conditions, each of which was subsequently stratified into case types on the basis of severity of the illness. The staging method subdivides each of the disease conditions into three basic stages of disease severity:

Stage I: Condition with no complications, or problems of minimal severity.

Stage II: Condition with local complications, or problems of moderate severity.

Stage III: Condition with systemic complications, or problems of maximal severity.[6]

The present study uses patient total charges as a proxy for their ideal total costs. That is, a given case-type classification is considered to exhibit economic meaningfulness in the degree to which the classification accounts for the variance in charges as opposed to costs. The appropriateness of this substitution is discussed below.

Not addressed in this study is the usefulness or equity of specific categories within each classification. Also not addressed are the issues of how hospitals should be grouped for the purpose of determining and applying the standard costs, how the standard costs should be compiled and how they should be used in calculating reimbursements.

Methods

To assess the technical appropriateness of a given classification for use in a prospective reimbursement scheme, one would ideally go through the following process:

1. Obtain patient records on a large, representative sample of admissions to hospitals of a given class, that is, that have similar staff resources, equipment availability and unit costs.
2. For each patient, determine the treatment of choice, considering both costs and benefits.
3. For each patient, calculate the cost of such treatment in an ideal institution of the given class.
4. Measure the homogeneity of these ideal costs within case type.

But since information on the amount of resources appropriate for the care of individual patients is generally not available, one might take, as a proxy, the amount of resources historically used for the care of individual patients. And since resource consumption figures themselves are not generally available for individual patients, charge figures were used in this study as second-order proxies for the corresponding appropriate levels of resource consumption.

Three kinds of errors are introduced by this substitution:

1. The bundle of resources actually used in the care of a given patient may be different from the ideal bundle. In fact, some patients would ideally have been treated in ambulatory settings rather than as inpatients.
2. The charges for the various goods and services supplied to a given patient may not accurately mirror the corresponding actual costs.
3. The actual costs, in turn, may not coincide with the costs for the same goods and services in an ideal hospital of the given class.

It may be seen that interhospital variation in patient management, charge structure and unit costs could, through its effect on the three kinds of errors, substantially inflate the measured heterogeneity within case type. In this study, the interhospital source of variation is eliminated by taking the measurements within hospitals. But the available data did not afford a method of reducing the remaining error variation, a large part of which may be due to within-hospital differences in the management of patients of the same kind. The analysis in this study assumes that the remaining error variation inflates the heterogeneity within case type equally among the three classifications. There appears to be no reason to suspect that this assumption is seriously in error.

Data Files

The data that were analyzed came from hospitals participating in the Study of Patient Charges of the Commission on Professional and Hospital Activities (CPHA). The Study of Patient Charges is an optional extension of the Professional Activity Study (PAS) in which the hospital adds each patient's total charge to the standard PAS data set and receives special reports analyzing these charges. Study of Patient Charges hospitals are a self-selected group of nonfederal, short-term hospitals in the

United States characterized by a wide variation in size, teaching status and region of the country.[3] Hospitals included in this study were the 50 that participated in the Study of Patient Charges during their entire 1976 fiscal year and that signed releases of their patient data for that time period for use in the study. The resulting file of base data contained 494,523 discharges. For each hospital in this group, all patients discharged during the 1976 fiscal year were included in the study with the following exceptions: a) births, excluded because charges recorded on births are unreliable since charges for newborn babies are often billed to the mothers; b) patients with invalid or missing data for age, principal diagnosis, length of stay or total charge (a charge was considered invalid if the average charge per day fell outside of wide, preset ranges).

Three additional data files were created from the base data file—a staged file, a trimmed file, and a file that was both staged and trimmed. The two staged files included only disease conditions for which a staging algorithm was then available; approximately 46 per cent of the patients in the base file were staged. The two trimmed files excluded patients who died in the hospital, were transferred to another hospital or stayed for more than 70 days.

The untrimmed files were used for analysis because reimbursement schemes would avoid a certain arbitrariness and complexity in application by minimizing exceptions, and it would be useful to know how the classifications would perform in such schemes. The trimmed files were also used because some current schemes do in fact trim the data when compiling weights and when using the weights in determining reimbursement amounts.[7]

Statistical Model

The task was to measure, for each case-type classification, the homogeneity of patient total charges within case type. Homogeneity, though, is traditionally expressed in terms of its opposite, heterogeneity, as manifested by the variance. To estimate this variance free from the confounding hospital effect, and to provide an estimate of total variance within hospital for comparison, a nested analysis of variance was employed for each classification. A full two-way analysis of variance was not done because there were too many levels in each of the explanatory variables, hospital and case type, to make it feasible. The model used for the nested analysis was:

$$Y_{ijk} = \mu + \alpha_i + \beta_{j(i)} + \epsilon_{ijk},$$

where Y_{ijk} = total charge for patient k in case type j in hospital i; μ = overall average of charge; α_i = average charge for hospital i, minus μ; $\beta_{j(i)}$ = average charge for case type j within hospital i, minus $(\mu + \alpha_i)$; and ϵ_{ijk} = charge of patient k in case type j in hospital i, minus $(\mu + \alpha_i + \beta_{j(i)})$. This model was fitted by least squares, yielding a mean square for hospitals; the mean square for case types within hospital, MS_T; and the mean square for patients within case type within hospital, MS_E.

The nature of the nested analysis may be clarified by the following discussion. If there were only a single hospital in the data set, one would obtain the case-type mean square MS_T and the residual mean square MS_E from the fitted model, and then calculate the corresponding variance components by the formulae:

$$\sigma_T^2 = (MS_T - MS_E)/n_0,$$

$$\sigma^2 = MS_E,$$

where n_0 = the weighted mean number of patients per case type

$$= (\Sigma n_j - \Sigma n_j^2/\Sigma n_i)/(t - 1),$$

where n_j = the number of patients in case type j and t = the number of case types represented by at least one patient.[8]

Since more than one hospital was included in the data, the estimates σ_f^2 and σ^2 were calculated as the appropriately weighted mean of the individual hospital estimates. By thus nesting case type within hospital, the analysis separated the confounding hospital effect. The NESTED procedure of the Statistical Analysis System (SAS) was used to perform these calculations.

Logarithmic Transformation

The analyses were performed using the charges just as they were found in the input data. Additionally, analyses were performed on a transformation of those charges in the two untrimmed data files. A logarithmic transformation was used to reduce the extremely large sampling error inherent in the highly skewed distributions characteristic of patient costs and charges, and to make additive the hospital effect, which may be multiplicative in the untransformed data. A pure logarithmic transformation, however, exaggerates variation among charges at the lower end of the distribution and somewhat distorts analyses purporting to compare variations in the charges themselves. Both disadvantages were reduced by adding an arbitrary constant, $200, to each charge before taking the logarithm. The $200 figure was suggested by some experience with length-of-stay data, where adding a day or two to the stay tended to make the logarithms normally distributed; $200 is a rough dollar equivalent of one or two hospital days in 1976 data.

An additional benefit of performing the parallel analyses was the procurement of evidence for determining whether small changes in the distribution of costs would affect the relative economic meaningfulness of the three classifications.

Results

Table 1 gives the results from the nested analyses of variance of patient charges. For ease of interpretation, the statistic tabulated for each analysis is the proportion of variance accounted for by case type within hospital. This statistic may be interpreted as a measure of relative homogeneity within case type. Little difference was found between the CPHA cross-classification and the DRG classification in this measure.

The CPHA cross-classification and the DRG classification each accounted for approximately a third of the within-hospital variance of patient charges in the full base data, which included all patients except newborn and a small contingent of patients who were excluded for missing data elements or unreasonable charge figures. These two classifications each accounted for nearly 40 per cent of the within-hospital variance when the data set was trimmed, i.e., when deaths, transfers and patients staying for more than 70 days were excluded. In the untrimmed data set, when the logarithmic transformation was used to reduce the erratic effect of occasional extremely high charges, the two classifications accounted for about half of the within-hospital variance.

When the data set was reduced to include only patients who belonged to a staged disease condition, the DRGs and the CPHA cross-classification were substantially more successful than the staging classification at accounting for variation in total charges. But when the case types of the staging classification were each split into two subtypes, for operated and nonoperated patients, the resulting classification was almost as successful as the DRGs and the CPHA cross-classification.

Discussion

The fact that the CPHA cross-classification and the DRGs had approxi-

TABLE 1. Per Cent of Within-Hospital Variance of Individual Patient Total Charges Due to Case Type*

Classification	Full Base Data: Untrimmed Data (N = 494,523) Variable Studied = Charge	Full Base Data: Untrimmed Data (N = 494,523) Variable Studied = log (200 + Charge)	Full Base Data: Trimmed Data† (N = 476,926) Variable Studied = Charge
CPHA cross-classification	33.0%	50.3%	38.8%
DRGs	31.5	47.2	39.9
Classification	**Staged Patients Only: Untrimmed Data (N = 201,767) Variable Studied = Charge**	**Staged Patients Only: Untrimmed Data (N = 201,767) Variable Studied = log (200 + Charge)**	**Staged Patients Only: Trimmed Data† (N = 195,315) Variable Studied = Charge**
CPHA cross-classification	40.4%	56.4%	45.6%
DRGs	40.5	55.0	48.9
Staging	29.5	44.1	34.8
Staging × operated/nonoperated	38.9	51.9	43.7

* The quantity tabulated is $\sigma_T^2/(\sigma^2 + \sigma_T^2)$, where σ_T^2 = estimated variance component due to case type within hospital and σ^2 = estimated variance component due to error, i.e., residual variance.

† The trimmed data excludes deaths, patients transferred to other hospitals and patients staying for more than 70 days.

mately the same overall heterogeneity within case type suggests that the use of either classification would result in approximately the same payments to hospitals in a prospective reimbursement scheme. This expectation is corroborated by a finding in another study in which a correlation of r = 0.97 was obtained between case-mix indices based on the two classifications. One index was constructed from the CPHA cross-classification, using charge weights compiled from Study of Patient Charges data, the other from DRGs, using New Jersey standard cost weights. The study data represented one year's discharges from 316 short-term hospitals in the United States; each index value was calculated for the totality of discharges from one hospital.[9]

The greater heterogeneity within case type in the staging classification suggests that reimbursements based on that classification would be less equitable than reimbursements based on either of the other two classifications, although the disadvantage would be slight if the operated/nonoperated split were added.

It may be noted that σ_T^2 is the combined result of the case-type main effect and the interaction between case type and hospital. Part of the interaction should rightfully be allocated, in this study, to the within-case-type heterogeneity, since the set of case-type weights to be used in a reimbursement formula would be the same for all hospitals in any hospital class. But since hospitals have not been classified for the purpose of developing sets of standard costs to use in the reimbursement mechanism, the proportion to be allocated could not be determined, and, in any case, an estimate of the interaction is not available from the nested model. Inability to make this allocation, however, affects all classifications in the study and is thought to add little bias to the comparisons among them.

As noted above, the observed variances of charge within case type, large by any standard, would be still larger if they in-

cluded interhospital differences, even if pricing differentials were not a factor. These large variances indicate that a standard cost allowance for a given case type in a particular hospital will often differ markedly from the ideal cost of the individual patients to whom it applies. As a result, a reimbursement scheme using any of these classifications would be inequitable if applied in a straightforward manner. The current New Jersey prospective reimbursement project greatly reduces this inequity by paying according to the weighted average of the state standard and a figure derived from the hospital's previous actual costs, giving the state standard a low weight in any case type in which the variance of costs in base data is high.[7]

The high variances of charges within case type appear to be due chiefly to the following causes. Many case types cover a wide range of medical conditions, whose treatments vary greatly in resource requirements. Patients with a given condition may vary in their reason for admission, e.g., for diagnosis, treatment or terminal care, and the cost of their management will accordingly vary greatly. A few patients with unusually severe manifestations of their disease, with unusual complications or with other factors causing extra expense, can add substantially to the variance. That the latter cause is an important influence is demonstrated by the drop in variance observed in Table 1 when the full patient file is replaced by the trimmed file, from which patients staying more than 70 days were excluded, or when the effect of extremely large charges is reduced by the use of the logarithmic transformation. Additional causes of high heterogeneity would be management and price differentials, and inaccuracy or incompleteness in the medical record, or in the coding and abstracting of the medical record data.

What then are the prospects of achieving a patient classification more satisfactory for use in hospital reimbursement? Developments in this direction, occurring since the present study was done, include the following:

1. DRGs have been redefined in terms of the *ICD-9-CM* diagnosis and operation codes. A larger and more nationally representative patient sample was used as the data base for the AUTOGRP process, to which a larger number of physicians gave input. But the limitation of the number of terminal groups to a few hundred will make serious heterogeneity in a number of groups unavoidable.

2. The CPHA cross-classification has been redefined in terms of *ICD-9-CM*, using 14 per cent more diagnostic categories, but the basic structure remains unchanged and likely would show little reduction in heterogeneity of patient costs or charges within case type.

3. The staging classification has been extended to cover all remaining disease conditions. But the overall heterogeneity within case type in the completed classification is not expected to be much, if any, smaller than that found here. This is because nearly half of short-term general hospital patients are already accounted for in the studied case types and because the remaining case types include residual categories. Overall, however, if the case types formed by the different stages of the disease conditions are further subdivided according to purpose of admission and management strategy, the heterogeneity within case type is likely to fall much lower than any variance found in this study. Support for this conjecture is provided by the substantial drop in variance achieved by simply splitting the case types into cells for operated and nonoperated patients.

4. The generalized management paths being developed under the direction of Young at Blue Cross of Western Pennsylvania also promise to result in much lower variances than those found in this study because of the detailed attention paid to clinical attributes, with emphasis on reason for admission to which costs are sensitive.[10]

5. A four-level illness-severity classification developed by Horn and her colleagues at the Johns Hopkins University has been tested on each of six diseases in three hospitals, and has yielded lower variances of length of stay and of patient total charge than DRGs, staging or generalized

management paths, according to a personal communication from Dr. Horn. Assuming that the further testing now under way should bear out the early promise of this classification, a possible impediment to its general acceptance for use in hospital reimbursement is that its application requires some use of judgment.

Conclusion

Diagnosis-Related Groups and the cross-classification of the Commission on Professional and Hospital Activities showed little difference in within–case-type heterogeneity of patient charges used as proxies for costs. The high levels of heterogeneity within case type preclude full use of cost standards for the case types of these classifications in hospital reimbursement schemes. Potential for the achievement of a classification that would exhibit less within–case-type heterogeneity of charges or costs is promised by current methodologic developments in the identification of disease stages, generalized management paths and illness-severity levels. Such a classification would make possible more equitable payments to hospitals under reimbursement schemes that take case mix into account.

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Comparing Classification Methods: Measurement of Variations in Charges, Length of Stay, and Mortality

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We define and examine three alternative systems for categorizing hospital patients. The first system is based on discharge abstract data alone; the second system is based on discharge abstract data that has been reabstracted from charts for completeness and accuracy; the third system is based on a severity-of-illness index within a diagnostic group. Using acute myocardial infarction patients as an illustrative example, we examine the homogeneity of these categorization systems with respect to charges, length of stay and mortality rates. Our results indicate that a measure of patient severity of illness is essential to produce homogeneous categories to study hospital productivity for utilization review assessment by PSROs, for planning purposes by Health Systems Agencies, for hospital rate setting by cost review commissions and for internal hospital financial management and utilization review studies.

MANY AGENCIES now collect hospital discharge abstract data to be used by Professional Standards Review Organizations (PSROs), Health Systems Agencies (HSAs) and state hospital rate-setting regulatory bodies. But hundreds of thousands of patient discharge abstracts are not useful as an unedited mass of data; they must be summarized or categorized if they are to be useful in quality-of-care and utilization review assessment by PSROs, in planning by HSAs, and in hospital rate setting by cost review commissions.

What sort of case-mix summarization or categorization system is best for these data? This article examines in detail three alternative systems based on: 1) discharge abstract data alone (DRG); 2) discharge abstract data that has been reabstracted from charts for completeness and accuracy (MD-DATO); and 3) a severity indexing of the diagnostic group (AS-SCORE). We have chosen acute myocardial infarction as the illustrative diagnosis, and we compare cases from a university teaching hospital with cases from a nonteaching community hospital.

One intuitive characteristic that a good categorization system should have is *medical meaningfulness* of the groups: patients with similar medical problems should be grouped together. A second characteristic of a good categorization system is *homogeneity* within the groups with respect to such chosen attributes as length of stay, severity of illness, clinical characteristics, charges, etc. Two common measures of homogeneity of data are 1) small values of the *coefficient of variation* (ratio of the

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standard deviation divided by the mean) and 2) large *reduction in variance*, i.e., the sum of squares in the subgroups are reduced as compared with the sum of squares in the initial group. A third characteristic of a good categorization system is that the inclusion into or exclusion from a group should depend on *intrinsic patient characteristics* and should not be influenced easily by physicians or hospital administrators. Variables such as "procedure or not," or "intensive care unit or not" can be influenced easily by physicians and hence should be used cautiously in forming a categorization system. Variables such as "age" and "interacting secondary diagnoses" are less subject to this sort of influence.

There exist many different variables with which to form a patient categorization system, but the best choice of variables depends on the ultimate use of the system. If the system is being developed for quality assurance purposes, one may wish to develop a categorization system in which the risk of inpatient death in each group is the same, assuming that the patients are receiving appropriate medical care.[1] If the system is being developed for examining length of stay (LOS), then one should have a categorization system such that the variation in LOS of cases in each group is minimized.[2] Or, if the system is being developed for reimbursement purposes, then one may wish to develop a categorization system in which the groups are determined so that the variation in charges or costs in each group is minimized.[3]

There are three categorization systems in use today. One is based on *ICDA codes* and contains as many groups as there are three or four digit ICDA codes (depending on which coding system is used). But this system produces about 1,000 groups (9,999 when the fourth digit code is used), which are very difficult to analyze in a comprehensive, coordinated fashion. A second system, the Professional Activity Study (PAS) A List, was formed by collapsing all the ICDA codes into 349 categories.[4] Each of these diagnostic categories is further divided into 20 subgroups, taking into account operation (yes or no), secondary diagnosis (yes or no), and age (five age groups). The PAS-A List has, therefore, almost 7,000 separate category subgroups.

A third common categorization system is the diagnostic-related grouping system (DRG) developed at Yale–New Haven Hospital.[2] This system has 383 groups that were formed from an original set of 83 major diagnostic categories (MDCs), such as acute myocardial infarction, congestive heart failure (CHF), pneumonia, etc. Each major diagnostic category was split into smaller subgroups using such variables as presence or absence of secondary diagnoses, presence or absence of procedures, and age, with the goal of producing medically meaningful groups with a minimum variation in LOS within each group. Evaluations of the DRG system can be found elsewhere.[5,6]

In this article we describe and compare several categorization systems. We focus on the disease and disease category *acute myocardial infarction* (AMI). For this condition, the ICDA code 410, the PAS A list grouping, and the DRG 121 contain exactly the same cases. In the DRG system, AMI is not only the major diagnostic category (MDC), but it is also the final terminal group (DRG). We shall use the DRG system as the standard, since it is widely used. We shall also describe two new categorization concepts, the physician-data-optimal (MD-DATO) system and a patient severity system.[7]

It is our intention to: 1) illustrate the strengths and weaknesses of discharge abstract data for cost reimbursement purposes; 2) compare the three systems—the DRG system, the MD-DATO system and the patient severity system—with respect to homogeneity of charges and LOS within each set of groupings and with respect to mortality rate analyses; and 3) distinguish between case mix and case-mix severity. In

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order to make these comparisons, we use: 1) discharge abstract data aggregated in the usual way, as employed by regulatory agencies; 2) several refinements of this aggregation system; and 3) detailed chart data. We give a detailed comparison using data from a 300-bed community hospital with no teaching programs, as well as data from a large metropolitan 1,000-bed medical center teaching hospital with over 20 residency training programs. The disease AMI was selected because it is one of the most difficult diseases to separate into homogeneous subgroups using discharge abstract data. That is the reason there was only one DRG for AMI patients. Also, it is one of the most CHARGE- and LOS-variable diseases in the HCFA Medicare data base.

Methods

In this section we describe briefly the MD-DATO system and the patient severity index, using AMI as an example. As part of a project to refine the existing DRGs with charge per case as the dependent variable and with systematic physician input, a physician specialty panel of five cardiologists and one internist considered all six cardiology major diagnostic categories (hypertensive heart disease, AMI, ischemic heart disease, arrythmia and slowed conduction, heart failure, and carditis and valvular disease) used in the DRG system.

The physician panel recommended that the medical meaningfulness and charge homogeneity of the AMI category could be improved by taking into account those secondary diagnoses that were most likely to explain differences in charges and mortality rates among AMI patients. Subsequent statistical analyses, using the 1977 Maryland discharge abstract data, were performed on the physician-generated groups as well as on minor modifications (partial collapsing) of these physician groups to make them more homogeneous with respect to charge. It is these modified groups that are the MD-DATO groups in this study. The data required for the DRG analyses and the MD-DATO analyses come from patient discharge abstracts; hence, patients can be placed into respective categories via computer. However, in the present study, because of its evaluative nature, we allocated the patients to the MD-DATO groups by a thorough review of the chart to make certain that discharge abstract coding omissions would not adversely affect the analyses.

In the MD-DATO system, the AMI patients are divided into four subgroups. These subgroups, based on the secondary diagnoses of the patient, are: 1) shock; b) pulmonary embolism and infarction, systemic embolism, heart failure, third degree heart block, cardiac arrest; c) hypertension, other arryhthmia (atrial fibrillation, atrial flutter, paroxysmal atrial tachycardia, ventricular fibrillation, flutter and tachycardia), venous thrombosis, recurrent pain; and d) other secondary diagnoses. A full list of all the diagnoses is available from the authors upon request.

The index of inpatient severity of illness[7,9] was developed in response to the need to compare case-mix severity among physicians whose practice patterns led to a wide variation in their patients' LOS, charges and mortality.[10] The patient-severity system is a simple, rudimentary classification system for severity of illness of medical patients that is based on clinical data from patients' medical records at the time of discharge. Statistical analyses of this index are presented elsewhere.[7] Efforts are now underway to study a new severity measure that is also applicable to surgical, obstetric, gynecologic and pediatric patients.

The severity index is called "AS-SCORE," an acronym that was derived from the principal attributes of this index:

A–Age of the patient.

S–Systems involved (cardiovascular, pulmonary, etc.).

S–Stage of disease [acute, chronic, chronic progressive, chronic with exacerbation, advanced (nonprogressive, progressive)].

CO–COmplications.

RE–REsponse to therapy.

The attributes assessed are *patient characteristics* such as age; *illness characteristics* such as organ systems involved, stage of the disease and assessment of complications; *results of therapeutic interventions;* and *outcomes.* Because the elements considered in this severity index are independent of a specific disease, the AS-SCORE index can be used with many medical diseases, medical major diagnostic categories or medical DRGs.

After review of the patient's medical record at the time of discharge, the patient is placed into one of four severity classes. Classes 1 through 4 are defined as follows (key decision items vis-à-vis AMI are italicized):

Class 1 includes patients with single system involvement in which either the disease stage is acute and nonprogressive or there are multiple, minor chronic disease states that do not interfere with normal activities of daily living. The patients have *no complications*, and their *response to therapy* is *complete*, prompt and sustained. There are no class 1 AMIs, since residual disease remains and is not eradicated by the therapy.

Class 2 includes patients with single or multiple system involvement. The disease stage in this class is acute or chronic (a duration of six months or more) and/or progressive. The patient may have complications that are treatable *without severe residual impairment*. The response to therapy is either complete or controlled, prompt or delayed, or sustained or intermittent. These patients include all AMIs without sustained complications and include cases with transient sinus tachycardia, atrial fibrillation or hypertension. AMI with pericarditis is also in this class. An example of a class 2 patient is one with an uncomplicated inferior AMI, hypertension and a history of previous AMI.

Class 3 includes patients with single or multiple system involvement. The stage of the disease in this class is acute or chronic, or chronic with exacerbation and/or progressive. There are *single or multiple severe complications with residual impairment*. The response to therapy is incomplete, usually delayed, temporary and intermittent. This class includes patients with persistent CHF, atrio-ventricular dissociation, transient second and third-degree heart block, papillary muscle dysfunction, extension or recurrent AMI, or successfully treated ventricular fibrillation. If a patient has an AMI and also has CHF, COPD, and diabetes, then he/she is in class 3.

Class 4 includes patients with single or multiple system involvement. In this class, the stage of the disease is advanced. There are single or multiple severe complications with residual impairment, and the *response to therapy is minimal or brief or there is no response*. This class includes patients with shock, pump failure, cardiac arrest or respiratory failure. An example of a class 4 patient is one with an AMI, CHF, ventricular tachycardia, cardiac arrest, hypertension, anemia and renal failure.

Specific procedures do not place a patient in one class, except to the extent that the procedures are associated with a diagnosis, e.g., implanted pulsation balloon or use of a respirator.

Results

In Table 1, the sample size, average LOS and coefficient of variation for LOS data in two Baltimore city hospitals for the year 1978 are shown. The same results are also included for CHARGES. We compare DRG 121 (AMI) with the initial refinements of AMI cases suggested by our cardiology panel (IHD-AMI and ARRY-AMI). The average LOS and coefficient of varia-

tion in the data grouped as DRG 121 (AMI as primary diagnosis only) are somewhat similar to the average LOS and coefficient of variation in the data set IHD-AMI. However, the average LOS is about two thirds as large in the data set ARRY-AMI; the sample sizes (n) are quite small, however.

Table 1 illustrates the usual methods (and refinements of these methods) currently used by regulatory agencies. From a bigger table with more hospitals, we selected these two hospitals with quite different LOS and charges (a community hospital and a medical center) to study with our more detailed methods. What follows are detailed analyses of DRG 21, the new MD-DATO groups for AMI and the severity groups within these two hospitals.

First, we examine the three methods of grouping. In the DRG system, the MDC AMI is exactly one DRG (because of the difficulty in breaking it into homogeneous subgroups), and it utilizes discharge abstract data. In the MD-DATO system, AMI is divided into four subgroups (based on secondary diagnoses described above) by computer. However, in our current study, we have identified these subgroups from a chart review to avoid any possible coding errors and, hence, to put the method in its most favorable light. In the severity system, the AMI patients are divided into four severity classes by chart review.

TABLE 1. LOS and CHARGES for Two Baltimore City Hospitals
Number of Cases in MDC (N), Number of Cases with AMI (n), Average LOS ($\bar{X}$) and Coefficient of Variation (CV) by Hospital and AMI Type, 1978

Hospital	AMI			IHD with AMI				Arrythmia with AMI				All AMI			
	N = n	$\bar{X}$	CV	N	n	$\bar{X}$	CV	N	n	$\bar{X}$	CV	n	$\bar{X}$	CV
LOS															
A. community hospital 1	203	17.5	47.2	207	2	12.0	11.8	138	—	—	—	205	17.4	47.3
B. medical center 2	238	13.6	66.3	938	16	11.8	72.3	246	6	11.7	52.2	260	13.4	66.4
CHARGES															
A. community hospital 1	203	4149	58.7	207	2	2512	8.7	138	—	—	—	205	4133	58.8
B. medical center 2	238	5480	70.3	938	16	5536	83.4	246	6	4537	48.4	260	5462	70.8

Charge Analyses

In Table 2, the charge results for both the medical center and the community hospital are shown. The data for all patients are split into the DRG group, the MD-DATO groups and the AS-SCORE groups. The top half of the table shows the sample size, the average charge, the coefficient of variation and the reduction in variance for all patients within the respective groups. The bottom half of the table shows the same results, but with the deaths and miscoded

cases omitted from the respective groups. The miscodes were cases that were coded with principal diagnosis AMI by the medical records department, but for which no corroborating evidence for AMI (any two of enzyme changes, typical chest pain or EKG changes) could be found when the charts were reviewed for the patient-severity classification. We also omitted all patients who left against medical advice and all patients who were transferred to another hospital.

First, examine the medical center data for each method of grouping patients. The results are based on 74 randomly selected patients during the period from January to June 1979 with AMI as the principal diagnosis. The average charge in this sample, $5339, is close to that in Table 1, $5480 (based on all 1978 cases).

The coefficients of variation for the MD-DATO groups tend to be only slightly smaller than that of the DRG. However, the coefficients of variation of the severity groups are about half the size of those for the DRG and MD-DATO groups. This is true for all data, as well as for the data with deaths and miscodes omitted. The smaller coefficients of variation indicate that the severity groups have better homogeneity with respect to charges per case. One exception is MD-DATO class A (shock) and severity class 4. Both of these groups contain very severely ill patients, many of whom die, and whose charges vary greatly; furthermore, the sample sizes in these groups are small.

There is no reduction in variance using the DRG, since there is only one group. There is only a 4 per cent reduction of variance using the MD-DATO groups for all the data and a 14 per cent reduction in variance using the severity groups for the same data. For the data with deaths and miscodes omitted, the corresponding reductions are 25 per cent for the MD-DATO groups and 63 per cent for the severity groups. The larger reduction in variance indicates that the severity groups are more homogeneous with respect to charges per case.

Separate analysis of variance (ANOVA) tests were computed for each of the grouping systems to determine if the mean values in the subgroups were significantly different. For the MD-DATO groups, the results were not significant ($F_{3,70} = 0.92$ for all data and $F_{3,48} = 57$ with deaths and miscodes omitted). The AS-SCORE means were significantly different ($F_{2,71} = 5.59$, $p < 0.015$ for all data and $F_{2,50} = 26.96$, $p < 0.001$ with deaths and miscodes omitted).

Next, we examine the community hospital data based on 75 randomly selected patients from the first half of 1979 with AMI as the principal diagnosis. Comparing our 1979 sample with data from all of 1978, we see that the average charge for our sample ($3961) is not much different from the average charge for all cases in 1978 ($4149). Here again, the severity groups show smaller coefficients of variation and larger reduction in variance. Separate ANOVA tests show that both the MD-DATO means and the AS-SCORE means are significantly different ($p \leq 0.05$).

If we now compare across each row of Table 2 (within each classification), we see that the coefficients of variation are almost always lower in the community hospital, i.e., the cases are more homogeneous than they are in the medical center. It is interesting to note, however, that the *differences* in coefficients of variation between the two hospitals are smallest for the severity groups; indeed, they are almost the same when deaths and miscodes are omitted.

For reduction in variance, the per cent reduction is the same for both hospitals using the patient-severity groups on all data (14 per cent), but it is more than 50 per cent greater in the medical center (63 per cent) than in the community hospital (39 per cent) for the data with deaths and miscodes omitted.

Within each final group, the average charge per case is almost always lower at the community hospital, but again the

TABLE 2. AMI—CHARGES

	All Data					
	Medical Center			Community Hospital		
	n	Average	CV	n	Average	CV
DRG–AMI	74	5339	0.77	75	3961	0.46
	Reduction in Variance = 0			Reduction in Variance = 0		
MD–DATO						
A–SHOCK	12	5071	0.98	4	3713	0.61
B–CHF	8	3733	0.60	34	4604	0.48
C–ARRYTH	26	4989	0.69	22	3845	0.34
D–OTHER	28	6239	0.75	15	2904	0.24
	Reduction in Variance = 0.04 $F_{3,70} = 0.92$, NS			Reduction in Variance = 0.07 $F_{3,71} = 3.43$, $p = 0.05$		
AS-SCORE						
2	31	3486	0.30	36	3254	0.23
3	23	6349	0.49	27	4653	0.38
4	20	7239	0.91	12	4730	0.63
	Reduction in Variance = 0.14 $F_{2,71} = 5.59$, $p < 0.015$			Reduction in Variance = 0.14 $F_{2,72} = 6.53$, $p = 0.005$		

	Deaths and Miscodes Omitted						
	Medical Center				Community Hospital		
	n	Average	CV	Mann-Whitney p = value	n	Average	CV
DRG–AMI	53	5729	0.67		61	3958	0.41
	Reduction in Variance = 0				Reduction in Variance = 0		
MD–DATO							
A–SHOCK	1	8785	0		1	5629	0
B–CHF	6	4516	0.45		24	4660	0.42
C–ARRYTH	22	5497	0.63		22	3845	0.34
D–OTHER	24	6118	0.64		14	2991	0.21
	Reduction in Variance = 0.25 $F_{3,45} = 0.57$, NS				Reduction in Variance = 0.18 $F_{3,57} = 4.09$, $p = 0.03$		
AS-SCORE							
2	28	3694	0.27	$p = 0.12$	36	3254	0.28
3	20	7058	0.38	$p = 0.01$	24	4920	0.35
4	5	11812	0.52	$p = 0.77$	1	8707	0
	Reduction in Variance = 0.63 $F_{2,69} = 26.96$, $p < 0.001$				Reduction in Variance = 0.39 $F_{2,58} = 19.07$, $p < 0.001$		

magnitude of these differences is much smaller within the severity groups. We tested the significance of the differences in charges between the two hospitals within each of the severity groups with deaths and miscodes omitted. Using the Mann-Whitney nonparametric two-sample test, we found the two-tailed probability of the difference in charges in class 2 patients to be $p = 0.12$, in class 3 to be $p = 0.01$, and in class 4 to be $p = 0.77$. We are investigating the reasons for these differences. There is no significant difference ($p > 0.05$) for the least severe and most severe AMI patients, but there is a significant difference between the community hospital and medi-

TABLE 3. AMI—LOS

	All Data					
	Medical Center			Community Hospital		
	n	Average	CV	n	Average	CV
DRG–AMI	74	11.82	0.65	75	14.93	0.43
	Reduction in Variance = 0			Reduction in Variance = 0		
MD–DATO						
A–SHOCK	12	6.83	1.03	4	7.25	1.05
B–CHF	8	9.63	0.68	34	16.32	0.44
C–ARRYTH	26	12.00	0.55	22	16.23	0.33
D–OTHER	28	14.43	0.57	15	11.93	0.27
	Reduction in Variance = 0.12 $F_{3,70} = 0.71$, NS			Reduction in Variance = 0.14 $F_{3,71} = 4.24$, $p < 0.02$		
AS-SCORE						
2	31	9.75	0.29	36	13.61	0.26
3	23	14.39	0.45	27	18.96	0.34
4	20	12.26	1.02	12	9.83	0.87
	Reduction in Variance = 0.03 $F_{2,71} = 2.24$, NS			Reduction in Variance = 0.26 $F_{2,72} = 17.58$, $p < 0.001$		

	Deaths and Miscodes Omitted						
	Medical Center				Community Hospital		
	n	Average	CV	Mann-Whitney p = Value	n	Average	CV
DRG–AMI	53	14.09	0.48		61	16.38	0.34
	Reduction in Variance = 0				Reduction in Variance = 0		
MD–DATO							
A–SHOCK	1	20.00	0		1	18.00	0
B–CHF	6	12.33	0.41		24	18.75	0.33
C–ARRYTH	22	13.09	0.51		22	16.23	0.33
D–OTHER	24	15.21	0.48		14	12.43	0.22
	Reduction in Variance = 0.01 $F_{3,96} = 0.69$, NS				Reduction in Variance = 0.19 $F_{3,97} = 4.38$, $p = 0.02$		
AS-SCORE							
2	28	10.39	0.21	$p = 0.001$	36	13.61	0.26
3	20	16.00	0.33	$p = 0.01$	24	20.13	0.29
4	5	27.40	0.34	$p = 0.50$	1	26.00	0
	Reduction in Variance = 0.60 $F_{2,49} = 33.21$, $p < 0.001$				Reduction in Variance = 0.37 $F_{2,59} = 17.05$, $p < 0.001$		

cal center for patients of moderate severity. Since severity of illness has been controlled for, we can now assess differences in use of technology in laboratory and radiology for these patients in the two institutions, in an effort to determine why class 3 patients are significantly more costly at the medical center, but class 2 and class 4 patients are not.

Length-of-Stay Analyses

In Table 3, the same breakdown of the AMI data is shown, but the variable LOS is now examined. Here, we again find that:

1. The average LOS in our sample of 1979 medical center patients (11.8) is about two days less than for all AMI patients in 1978 (13.6 in Table 1). The average LOS in our sample of community hospital patients is 14.9 days, versus 17.5 days for all of 1978. These changes undoubtedly represent changes in practice patterns for AMIs. It is interesting that we find a decrease in LOS from 1978 to 1979, but Table 2, as compared with Table 1, showed almost no change in charges for the same period.

2. The coefficients of variation tend to be smallest in the severity index (AS-SCORE) groups for each hospital.

3. The community hospital tends to have smaller coefficients of variation than the medical center within each row of the table.

4. The reduction in variance tends to be larger for the severity groups in each hospital.

5. The medical center tends to have a lower median and lower average LOS than the community hospital within each group, and these differences are significant at $p \leq 0.01$ for class 2 and class 3 patients with deaths and miscodes omitted.

6. ANOVA tests show significant differences in means of the AS-SCORE subgroups with deaths and miscodes omitted for the medical center, and all means different for the community hospital.

Table 4 shows how the severity and the MD-DATO groups relate to each other. MD-DATO class A (shock) contains mostly AS-SCORE class 4 patients, but within each of the remaining MD-DATO groups there is wide variation in severity. Thus, these two different methods of grouping patients are not equivalent. The groups based on secondary diagnoses tend to contain patients in all severity levels. One exception, however, is MD-DATO group D (Other) in the community hospital. Almost all of its patients are class 2, as compared with the medical center, which has patients of all three severity levels in MD-DATO group D. This correspondence accounts for the low coefficients of variation for group D patients in the community hospital in Tables 2 and 3.

Table 5 shows that the death rate in our sample at the medical center is 20 per cent, as compared with 13 per cent at the community hospital. (Using the total 1978 discharge abstract data, it was 16 per cent and 10 per cent, respectively.) However, when we take severity into account for the sample data, we see that the death rate at the medical center is actually lower, 75 per

TABLE 4. Relationship Between MD-DATO and AS-SCORE

MD-DATO	AS-SCORE Class	Medical Center		Community Hospital	
		Number of Cases	Average Severity	Number of Cases	Average Severity
A					
	2	0	3.92	0	3.75
	3	1		1	
	4	11		3	
B					
	2	3	2.75	6	3.06
	3	4		20	
	4	1		8	
C					
	2	15	2.50	16	2.27
	3	9		6	
	4	2		0	
D					
	2	13	2.75	14	2.13
	3	9		0	
	4	6		1	

TABLE 5. Death Rates

	Medical Center		Community Hospital	
	n	Death Rate	n	Death Rate
DRG-AMI	74	15/74 = 20%	75	10/75 = 13%
MD-DATO				
A-SHOCK	12	11/12 = 92%	4	3/4 = 75%
B-CHF	8	1/8 = 13%	34	6/34 = 18%
C-ARRYTH	26	0/26 = 0%	22	0/22 = 0%
D-OTHER	28	3/28 = 11%	15	1/15 = 7%
AS-SCORE				
2	31	0/31 = 0%	36	0/36 = 0%
3	23	0/23 = 0%	27	0/27 = 0%
4	20	15/20 = 75%	12	10/12 = 83%

Severity Comparisons

	Medical Center	Community Hospital
	n = 74	n = 75
AS-SCORE		
2	42%	48%
3	31%	36%
4	27%	16%
—		
Average Severity	2.85	2.68

cent in class 4 patients compared with 83 per cent in class 4 patients in the community hospital. Although the difference in these death rates is not significant with such small sample sizes, it does show that the crude death rate alone can be misleading; one needs to take severity of illness into account.

We examined the mortality cases separately to determine in what ways these patients differed in their charges and LOS. The results are shown in Table 6 and are summarized as follows:

1. The coefficients of variation are much larger at the medical center than at the community hospital for both charges and LOS. Apparently, there is more variability in treatment at the medical center for those patients who die.

2. Although the mean charge is larger at the medical center, the median charge is smaller, and the difference between the two institutions, using the Mann-Whitney test, is not significant ($p = 0.62$). The mean charge is larger because the medical center had a few very high charge deaths.

3. The median and mean LOS are less at the medical center, but the difference is not significant ($p = 0.42$).

Discussion and Summary

We have examined in detail three different methods for grouping patients and for adjusting inpatient LOS, charge and death rate data for AMI patients.

The first method utilizes the DRG method and is based entirely on the discharge abstract. This method was found to be the least adequate for grouping AMI patients when compared by two statistical criteria of homogeneity (coefficient of variation and reduction in variance). The DRG method is clearly inadequate for this disease condition. The entire DRG system is now being redefined using the new ICDA-CM-9 data base on LOS from the Commission on Professional and Hospital Activities.

The second method (MD-DATO) groups cases using secondary diagnoses.

TABLE 6. Mortality Cases of AMI

	Medical Center		Community Hospital	
	Charges	LOS	Charges	LOS
N	15	15	10	10
Median	3317	3	3808	6
Mean	5276	6.47	4050	7.1
CV	1.15	1.27	0.69	0.86

The assumption is that secondary diagnoses will add sufficient information to the principal diagnosis of AMI that the homogeneity of the groupings will be statistically improved. Five cardiologists and one internist established subgroupings for AMI based on the secondary diagnoses of shock, congestive heart failure and/or severe arrhythmia, hypertension and/or other minor arrhythmias, and other secondary diagnoses. Subgrouping AMIs by these secondary diagnoses slightly improved the group homogeneity (Tables 2 and 3) as seen by smaller coefficients of variation and larger reductions in variance. Further analyses using new data sets and refinements of the MD-DATO grouping method for discharge abstract data show the same slight improvements in homogeneity. This suggests that for AMI cases, discharge abstract data manipulation may have little potential for producing CHARGE and LOS-homogeneous groups.

The third method uses an implicit four-level measure of patient severity. The statistical criteria using this method are markedly better than those for either the DRGs or the groupings based on physician diagnoses (MD-DATO). A substantial reduction in variance and much smaller coefficients of variation are achieved. Thus, patient groupings that account for severity are essential for appropriate comparisons of one hospital with another for utilization review, reimbursement or quality studies. A simple measure of patient severity adds greatly to an understanding of the data.

The comparison of the medical center and community hospital data showed that the medical center hospital had a substantially more variable patient population with respect to CHARGES and LOS. These patients were treated in a shorter time period at the medical center (Table 3), and their least complicated and most complicated costs were approximately the same (Table 2) as those of patients at the community hospital. After adjustment for severity, the death rate at the medical center hospital changed from higher than that at the community hospital to lower than that at the community hospital, although not significantly lower.

Recognizing that the descriptions of the four AS-SCORE severity classes do not give much guidance to raters, we are now undertaking further research to refine the system. Although the AS-SCORE system has been successful, we are developing a severity index that is even more precisely defined and, therefore, more teachable and more reliable.

Many different agencies need to know how to handle patient discharge data properly. Our study examined three different methods: the discharge abstract, the total chart to get accurate secondary diagnoses and a structured implicit severity measure. Slee[11] has suggested that additional data need to be incorporated into discharge abstracts so that they can be more useful in making decisions about medical care. Our study indicates that a measure of patient severity can be very useful in measuring

patient characteristics and hospital productivity.

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Access to Postpartum Sterilization in Southeast Brazil

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All women hospitalized for delivery over a ten-week period at the largest maternity hospital in Campinas in the State of São Paulo, Brazil, were questioned about their interest in and plans for sterilization. Results from a categorical data analysis indicate that among the study variables, cesarean delivery was the necessary condition for postpartum sterilization and was significantly associated with the patient's ability to pay for services. Further, the variability in the proportion of women sterilized postpartum was almost perfectly explained by a linear model with main effects for parity and for the patient's ability to pay for services.

BRAZIL HAS the largest population in Latin America, with early 1980 census estimates of between 115 and 118 million.[1] Fertility began to decline around 1965, and recent surveys indicate a continuing decrease. The population growth rate was 2.8 for the period between 1965 and 1970, and was estimated to be 2.4 for the period from 1975 to 1979.[2]

During the early 1970s, the government was opposed to family planning, but by 1977 it had modified its position to the extent of promising to provide contraceptives to women for whom pregnancy would create a severe health risk; however, this pledge has not yet been implemented.[3]

One of the country's most important methods of family planning is female sterilization. Data from a recent contraceptive survey indicate that it is the second most prevalent method in São Paulo, the country's richest and most populous state.[4] Of currently married women between the ages of 15 and 44, 64 per cent were using some contraceptive method; of these, 25 per cent had been sterilized. Seventy-five per cent of all sterilizations were performed for women in the year of their last delivery.

Although data on the percentage of sterilizations in conjunction with cesarean delivery are unavailable for the state of São Paulo, surveys conducted in the summer of 1980 reveal that in two Northeast states (Rio Grande do Norte and Pernambuco) 60 per cent of the sterilizations were carried out at the time of cesarean delivery (unpublished data).

Couples able to afford modern methods have many options, so it is not surprising to find that the use of oral contraceptives and condoms is positively correlated with in-

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come[4] or that among women who do not want more children, the percentage sterilized rises with family income.[5]

Twenty years ago, sterilization was performed in Brazil only if medically indicated,[6] but, today, social and economic factors contribute greatly to its justification. Although the Brazilian Medical Ethics Code condemns sterilization, it is permitted in "exceptional" cases when certified by three physicians. However, the rationale for exceptions is not explicit, and many physicians perform the procedure by interpreting the Code to include women who would be at high risk if they become pregnant.

Women who have had previous cesarean deliveries are at high risk, and when they undergo this surgery for the third time, they are almost always sterilized. It may be more difficult for a woman who has never had a cesarean to qualify for a sterilization unless she can meet the other criteria of the "exceptional" cases.

Although the Brazilian Penal Code does not refer to male or female sterilization,[6,7] these procedures are not permitted by the Ministry of Health within its Program of Maternal–Child Health. This attitude is reflected in the national health insurance program, which does not reimburse physicians for sterilization services. Moreover, since the largest employer/employee health insurance plan relies on these government schedules to determine rates of compensation for physician services, it, too, omits payment for surgical sterilization.

As a consequence of government policy, insurance coverage includes the cost of delivery and, usually, a cesarean delivery, but not the concurrent sterilization. Because of the additional personnel, medications, anesthetics and longer hospitalization required, reimbursement rates are necessarily higher for cesarean than for vaginal deliveries, and more generous under private sector plans than through the national insurance system.

Information gathered in four hospitals in the city of Campinas indicates that access to sterilization among women hospitalized for obstetric delivery depends on their socioeconomic status.[8] Although the data collection instrument used was not specifically designed to study access, it may be inferred from these data that sterilization is not equally available to all women.

To gain more information concerning access to sterilization, a study was undertaken at a large maternity hospital in Campinas, chosen because it serves patients of widely varied socioeconomic status and, consequently, of different abilities to pay for surgery.

Data and Method

The study was conducted over a ten-week period, from December 1979 through February 1980. An interview was scheduled after delivery but before discharge for women giving birth during this time. They were asked a number of questions: Did they want any more children? Had they heard about sterilization, and, if so, had they planned to be sterilized? If they had planned to be sterilized, was the procedure actually carried out? If not, why not? And were they considering alternative plans for sterilization? Women who said they were not interested in this method of contraception were asked the reason(s) for their attitude.

During the study period, 2,279 women gave birth, and interviews were completed for 2,194 of them (96.3 per cent). Some information was obtained for 72 of the other cases, but none for the remaining 13.§

The potential market for sterilization services consists of women who want no more children. However, not all women who fall into this group are likely to want to

§ Payment status and type of delivery account for the major differences between the women for whom an interview was and was not completed.

make an irreversible decision to limit their fertility. In an effort to confine the analysis to those who might be expected to have completed their families and not be unduly influenced by the circumstances of pregnancy and delivery, the population analyzed has been limited to the 927 married women who have at least two children, including the current delivery, and are between the ages of 20 and 44 (henceforth described as women who desire no more children).

The analysis proceeds in steps, the first of which is descriptive, concerning distributions of age, parity (after delivery), monthly family income, education, type of payment for medical services and method of delivery among the 927 women who desire no more children. However, all of them will not necessarily choose sterilization. Therefore, in the second stage of the analysis, attention is directed toward describing how the population desiring no more children chooses sterilization as the preferred method of family planning. The last phase of the analysis is concentrated on the subset of women preferring sterilization services. In this third stage, frequent use is made of methods of estimation and hypothesis testing from cross-classified data.

Results and Analysis

The Market for Sterilization

The second column of Table 1 presents data on the characteristics of women who desire no more children. More than 25 per cent of the women are from 20 to 24 years of age, and more than 60 per cent are under 30; almost 30 per cent have had exactly two children; more than 40 per cent have not completed primary school (less than four years), and less than 20 per cent have eight or more years of education. More than 50 per cent have a monthly family income under $300, and for less than 20 per cent it is at least $500; income is unknown for 14 per cent. Close to 38 per cent of the women had cesarean deliveries; the others, except for one whose type was unrecorded, had vaginal deliveries.

Almost 10 per cent are private patients, 7 per cent are covered by employer/employee–financed plans (*convenio*), more than 70 per cent by government insurance, and 20 per cent have no medical coverage. All women are classified as private patients if they were assigned to the private section of the hospital, and included in this group are some insured patients. It is assumed that women assigned to the "private" section of the hospital will be treated equally, despite the differences in type of payment for services. This inference is borne out by the hospital policy requiring the physician's permission to interview a woman assigned to a private room, but not patients in other accommodations.

Convenio includes all women who pay for their care through a privately financed insurance plan but do not stay in a private room. "Government insured" encompasses the group paying for care with public insurance. "Indigent" includes all women without any medical insurance.

The higher the woman's level of education, the more likely she is to be a private or a *convenio* patient. Similarly, the higher her family's income, the more apt she is to be a private patient. However, 14 per cent of the women did not know or did not wish to report their family income. Because of this large unknown proportion, and since payment status is closely related to income, greater attention will be paid to the impact of the other characteristics (age, parity, education, payment status and type of delivery) on access to sterilization.

Information Concerning Sterilization

To obtain a sterilization, a woman must first have heard of the procedure. Column 3 of Table 1 shows that almost nine out of ten women who want no more children

have heard about sterilization. Further, except for parity, the proportion having heard of sterilization increases monotonically with increasing levels of the characteristics in column 1 of Table 1. Indigent patients are least likely (79 per cent) and private patients are most likely (98 per cent) to have heard of it. Women who had cesarean deliveries are more likely to have heard of sterilization (95 per cent) than those giving birth vaginally (86 per cent).

Among the patient characteristics of interest, payment status has the largest spread in the percentage of patients who have heard of sterilization. A sterilized friend is the most important source of knowledge (63 per cent), and a physician is the second (16 per cent). However, private patients are more likely to have received this information from a doctor (25 per cent) than are *convenio* (16 per cent), nationally insured (15 per cent) or nonpaying patients (18 per cent).

Plans for Sterilization

Of all women who want no more children and have heard of sterilization, as

TABLE 1. Desire for No More Children, Knowledge of and Plans for Sterilization of Married Women Aged 20–44, With at Least Two Children, by Selected Characteristics

Characteristic	A Number Desiring No More Children	Have Heard of S* Per Cent of A	Have Heard of S* B Number of	S* Plans Per Cent of B
All characteristics	927	89.2	827	58.2
Age				
20–24	263	83.6	220	36.4
25–29	310	91.0	282	58.5
30–34	208	90.9	189	76.7
35–39	115	93.0	107	70.1
40–44	31	93.5	29	55.2
Parity				
2	276	89.5	247	30.0
3	291	90.4	263	65.4
≥4	360	88.1	317	74.1
Monthly family income				
$ 0–$199	285	84.2	240	58.3
$ 200–$299	185	87.0	161	57.1
$ 300–$499	163	93.9	153	57.5
≥$500	163	98.8	161	68.3
Unknown	131	85.5	112	45.5
Education (years)				
0–3	381	82.7	315	61.0
4	240	92.1	221	57.9
5–7	131	91.6	120	54.2
≥8	175	97.2	171	56.1
Payment status				
Indigent	94	78.7	74	40.5
Government insured	662	89.1	590	58.1
Convenio	66	93.9	62	61.3
Private	92	97.8	90	72.2
Unknown	13	84.6	11	45.5
Delivery type				
Vaginal	576	85.5	494	44.9
Cesarean	350	94.8	332	78.0
Unknown	1	100.0	1	—

* S = Sterilization.

shown in column 5 of Table 1, 58 per cent said that they planned to be sterilized. The percentage of women who plan to be sterilized is curvilinear with age, with 36 per cent of women between the ages of 20 and 24 planning to be sterilized, as compared with 77 per cent between the ages of 30 and 34 and 55 per cent from 40 to 44 years of age. As parity increases, so does the proportion planning sterilization. Among women at parity 2, 30 per cent plan to be sterilized, as compared with 65 per cent at parity 3 and 74 per cent who have given birth to four or more children.

Education and family income up to $500 monthly show little association with plans for sterilization. However, 10 per cent more women at the highest monthly income level plan to be sterilized than those less privileged.

Private patients were more likely to say they planned to be sterilized than insured patients, and insured more than the indigent. Finally, women having cesarean deliveries were almost twice as likely to be planning sterilization as those who had vaginal deliveries.

Information Concerning Sterilization Facilities

To be sterilized postpartum, a woman must know that services are offered at the hospital where her baby is born. Column 3 of Table 2 shows that 78 per cent of women who want no more children and who have heard about sterilization know that it is available at the hospital. This proportion is lowest for the age group between 20 and 24 years and highest for women 30 years of age and over, an expected relationship since many under the age of 30 may be less strongly committed to the decision to be sterilized than older mothers and, therefore, have sought less information about the procedure. Knowledge shows little variation with parity, but is surprisingly low for women at parity 4 and over, compared with women at lower parities. Knowledge concerning services increases with income and education, and only 60 per cent of women who had vaginal deliveries were as likely to be as knowledgeable as those who had cesarean deliveries. The relationship to payment status is particularly strong. More than 95 per cent of private patients know that sterilization is offered at the hospital, as compared with only 43 per cent of nonpaying patients.

The varied answers to the questions concerning availability may be a function not only of the woman's knowledge of the existence of the hospital's sterilization facilities, but also of her perception that these services are being offered to her. It may be that some women, particularly those from the lower socioeconomic groups, answer negatively because they believe that the facilities are not available to them, rather than that the hospital does not actually possess such facilities.

Who Gets Sterilized?

The last two columns on Table 2 display, respectively, the numbers and percentages of women sterilized among those planning it who also knew that services were available at the hospital. Of these 376 women, 226 (60 per cent) received sterilizations. The proportion sterilized increases with income, education and for age groups up to those between 35 and 39 years of age. For parity (including the current birth), the percentage sterilized reaches a maximum (74 per cent) at parity 3. Payment status has an important influence on who is sterilized. More that 80 per cent of the private patients who planned sterilization were sterilized, as compared with 68 per cent of the *convenio*, 54 per cent of the government insured and 46 per cent of the indigent patients. Finally, women with cesarean deliveries were 16 times more likely to receive postpartum sterilization than those who had vaginal deliveries.

To investigate further the influence of payment status on who is sterilized, atten-

TABLE 2. Knowledge About Availability of Sterilization and Attainment of Postpartum Sterilization for Selected Characteristics of Married Women Aged 20–44 Who Have at Least Two Children, Desire No More Children and Are Planning Sterilization

Characteristic	A Number of S* Plans	Know S* Offered at Hospital		Postpartum S*	
		Per Cent of A	B Number of	Per Cent of B	Number
All characteristics	481	78.2	376	60.1	226
Age					
20–24	80	66.3	53	54.7	29
25–29	165	77.6	128	56.3	72
30–34	145	84.1	122	63.1	77
35–39	75	80.0	60	66.7	40
40–44	16	81.3	13	61.5	8
Parity					
2	74	81.1	60	48.3	29
3	172	81.4	140	73.6	103
≥4	235	74.9	176	53.4	94
Monthly family income					
$ 0–$199	140	70.7	99	47.5	47
$ 200–$299	92	78.3	72	44.4	32
$ 300–$499	88	83.0	73	63.0	46
≥$500	110	89.1	98	76.5	75
Unknown	51	66.7	34	76.5	26
Education (years)					
0–3	192	68.8	132	47.7	63
4	128	78.1	100	61.0	61
5–7	65	87.7	57	68.4	39
≥8	96	90.6	87	72.4	63
Payment status					
Indigent	30	43.3	13	46.2	6
Government insured	342	76.7	263	54.0	142
Convenio	38	97.4	37	67.6	25
Private	65	95.4	62	83.9	52
Unknown	5	20.0	1	100.0	1
Delivery type					
Vaginal	222	57.2	127	5.5	7
Cesarean	259	96.1	249	87.9	219
Unknown	—	—	—	—	—

* S = Sterilization.

tion will be restricted to the 375 women who were both planning sterilization and aware of its availability at the hospital (225, i.e., 60 per cent were sterilized).[1]

The variables of interest in this analysis are postpartum sterilization, payment status, age, education, parity and type of delivery, each classified at two levels. Payment status is defined as public (indigent and government insured) and non-public (*convenio* and private). Age is dichotomized by year groups, 20–29 and 30–44, and education by year groups, zero–four and at least five. Because of the practice of performing sterilizations for women having their third cesarean delivery, parity (including present birth) is

[1] There are 375 women available for this analysis, instead of 376 as shown at the top of column 4 of Table 2, because one woman could not be classified by payment status.

dichotomized by two and at least three, and the method of delivery is categorized as vaginal or cesarean.

The strongest first-order association between the explanatory variables and sterilization is exhibited by the method of delivery (Pearson $\chi^2 = 236.9$, 1DF, $p << 0.01$). Among women who had cesarean deliveries, 88 per cent were sterilized, compared with 6 per cent of the others. In descending rank of importance of first-order association with sterilization, the explanatory variables following method of delivery are payment status, education, parity and age. However, the association between age and sterilization does not achieve significance at $\alpha = 0.05$.

In general, to be sterilized postpartum a woman must have an abdominal delivery. For patients in this category, the proportion sterilized (0.88) is the same regardless of payment status. However, a significantly greater proportion of women in the nonpublic payment subpopulation (0.83 versus 0.60) had cesarean births (Pearson $\chi^2 = 18.8$, 1DF, $p < 0.01$). Non public payment patients who had vaginal deliveries receive proportionally more sterilizations (0.25 versus 0.03) than public payment patients (Pearson $\chi^2 = 13.4$, 1DF, $p < 0.01$).

Cesarean delivery is, in general, the necessary condition for postpartum sterilization and, as shown above, is significantly associated with payment status. Consequently, it is of interest to focus on the association between sterilization and each of the explanatory variables (age, parity and education), while controlling for payment status. When payment status is controlled using the Mantel-Haenszel procedure,[9] only parity remains significantly associated with sterilization (Mantel-Haenszel $\chi^2 = 8.2$, 1DF, $p < 0.01$).

A close look at the four subpopulations defined by the levels of payment status and parity (Table 3) reveals that the respective proportions of women sterilized can be represented almost perfectly by an additive model with main effects for payment status and parity (i.e., there is no interaction between payment status and parity). The methods of Grizzle, Starmer and Koch[10] are applied to estimate and test the statistical significance of the main effects. Table 4 displays estimates of the payment status and parity effects, along with test statistics for their significance. Both main effects are highly significant. The estimates indicate that, regardless of parity, the difference in the proportions sterilized between women whose payment is nonpublic and public is 26 per cent. Similarily, the difference between the per cent of women of parity 3 or more and of parity 2 who were sterilized is 18 per cent, regardless of payment-status level.

Why Women Are Not Sterilized

Of the 375 women who planned to be sterilized and knew about available ser-

TABLE 3. Prevalence of Sterilization by Payment Status and Parity (for the 375 Women Who Were Both Planning Sterilization and Aware That It Was Available at the Hospital)

		Sterilized		
		Yes		No
Payment Status	Parity	Number	(Proportion)	Number
Public	2	16	(0.38)	26
	≥3	132	(0.56)	102
Nonpublic	2	16	(0.64)	9
	≥3	61	(0.82)	13

TABLE 4. Analysis of Variance Table for a Main Effect Model of the Proportion of Women Sterilized (for the 375 Women Who Were Both Planning Sterilization and Aware That It Was Available at the Hospital)

Source of Variation	Estimate of Effect	DF	χ^2 Test Statistic
Payment status	0.26	1	27.0*
Parity	0.18	1	8.1*

* Denotes significance at $\alpha = 0.01$.

vices, 40 per cent were not sterilized postpartum. The most frequent reason given was type of delivery (38 per cent); of the women who had vaginal deliveries, 48 per cent (57/120) gave this as a reason for failure to be sterilized. Other frequent explanations for not having undergone sterilizations were: a) it was not customary for the doctor to do them, or he did not want to operate (29 per cent); b) the physician considered that the woman was too young or that she did not have enough children (15 per cent); and c) the woman either did not discuss the possibility of, or actually arrange for, sterilization with her doctor (7 per cent).

Conclusions and Policy Implications

Data from this study show that the method of payment for care substantially influences the eventuality of the sterilization. Wealthier women who are private or *convenio* patients are more likely to be sterilized than are the poor, whose care is financed through government insurance or who are indigent. Results also show that women sterilized postpartum almost always have had cesarean deliveries. Regardless of whether she is sterilized, a cesarean delivery is more likely as the socioeconomic status of the woman rises.

What then can be done to increase access to this method of family planning among poor women in Brazil? A more liberal interpretation of the Medical Ethics Code that would consider women to be at high risk for reasons other than those associated with previous cesarean birth would improve access to postpartum sterilization. As a consequence of current policies, women with high family income who have a history of cesarean deliveries may qualify for sterilization on medical grounds, whereas poor women who have had vaginal deliveries are turned down for sterilization because of the very nature of their delivery.

Physicians who do perform postpartum sterilizations cannot charge for their services under the national or private insurance plans. Other countries have increased access to sterilization by modifying medical insurance plans (thus making it more attractive for surgeons to perform the operation) or by paying physicians directly. In the United States, as in many other countries, most medical insurance plans cover both tubal ligations and vasectomies, and the extension of coverage to include sterilization has doubtless increased the number carried out.

Brazil is well on its way to modifying its posture regarding family planning, and there are signs that a publicly supported program will soon be undertaken. The Minister of Health, Waldir Arcoverde, recently announced official adoption of a family planning program throughout the country that will include free access to tubal ligations.

This article has demonstrated that access to sterilization in Brazil is differentially affected by legal and institutional constraints on delivery of services. These results may

be generalized to other medical services and geographic locations. The present controversy in the United States over family planning and abortion could give rise to conditions similar to those in Brazil.

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